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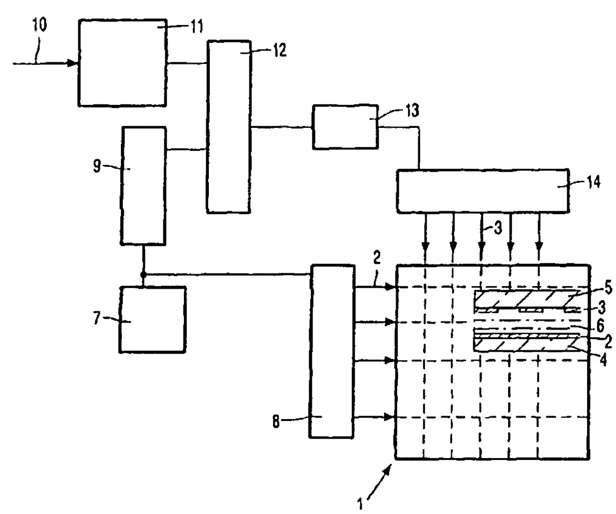

(57) Abstract: In whitelist-based authentication, a first device (102) in a system (100) authenticates itself to a second device (103) using a group certificate identifying a range of non-revoked device identifiers, said range encompassing the device identifier of the first device (102). Preferably the device identifiers correspond to leaf nodes in a hierarchically ordered tree, and the group certificate identifies a node (202-207) in the tree representing a subtree in which the leaf nodes correspond to said range. The group certificate can also identify a further node (308, 310, 312) in the subtree which represents a sub-subtree in which the leaf nodes correspond to revoked device identifiers. Alternatively, the device identifiers are selected from a sequentially ordered range, and the group certificate identifies a subrange of the sequentially ordered range, said subrange encompassing the whitelisted device identifiers.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Display device

The invention relates to a display device comprising a liquid crystal material between a first substrate provided with row or selection electrodes and a second substrate provided with column or data electrodes, in which overlapping parts of the row and column electrodes define pixels, drive means for driving the column electrodes in conformity with an image to be displayed, and drive means for driving the row electrodes.

Such display devices are used in, for example, portable apparatuses such as laptop computers, notebook computers and telephones.

Passive-matrix displays of this type are generally known and, for realizing a high number of lines, they are increasingly based on the STN (Super-Twisted Nematic) effect. An article by T.J. Scheffer and B. Clifton "Active Addressing Method for High-Contrast Video Rate STN Displays", SID Digest 92, pp. 228-231 describes how the phenomenon of "frame response" which occurs with rapidly switching liquid crystal materials is avoided by making use of "Active Addressing". In this method, all rows are driven throughout the frame period with mutually orthogonal signals, for example, Walsh functions. The result is that each pixel is continuously excited by pulses (in an STN LCD of 240 rows: 256 times per frame period) instead of once per frame period. In "multiple row addressing", a (sub-)group of p rows is driven with mutually orthogonal signals. Since a set of orthogonal signals, such as Walsh functions, consists of a plurality of functions which is a power of 2, i.e. 2^S, p is preferably chosen to be equal thereto as much as possible, i.e. generally $p = 2^S$ (or also $p = 2^S-1$). The orthogonal row signals $F_i(t)$ are preferably square-wave shaped and consist of voltages $+F$ and $-F$, while the row voltage is equal to zero outside the selection period. The elementary voltage pulses from which the orthogonal signals are built up are regularly distributed across the frame period. In this way, the pixels are then excited 2^S (or (2^s-1)) times per frame period with regular intermissions instead of once per frame period. Even for low values of p such as $p = 3$ (or 4) or $p = 7$ (or 8) the frame response appears to be suppressed just as satisfactorily as when driving all rows

simultaneously, such as in "Active Addressing", but it requires much less electronic hardware.

However, it appears that, when the column outputs do switch each selection time, e.g. when displaying a one-line on and one-line off picture or a chess picture, this results in high display currents and thus in a high power consumption both in the display device and in the driver circuit.

It is, inter alia, an object of the invention to provide a display device of the type described above, in, which a minimal number of artefacts occurs in the image.

To this end, a display device according to the invention within a frame period sequentially supplies groups of p row electrodes with mutually orthogonal signals obtained from at least two different orthogonal functions.

It can be proven that in "multiple row addressing" one can use multiple (two, three,...) orthogonal (sub)matrices within one frame. This opens possibilities to reduce the number of transitions in the column signal, reducing the display and module power consumption e.g. by using suitable rotating orthogonal matrices. In this respect it is noted that in WO 01/61678 a device for multiple row addressing is shown, which is driven with periodically repeated sets of elementary voltage pulses. However here the same pulse pattern is repeated, said pulse pattern being chosen from sets of 4 (or more) different orthogonal functions which have a less varying frequency content than pulse patterns based on e.g. a set of Walsh functions.

The invention will now be elucidated with reference to an embodiment and the drawings in which

Fig. 1 shows diagrammatically a display device in which the invention is used, and

Fig. 2 shows the display of Fig. 1 in a more functional way

Fig. 3 shows an equivalent circuit of a picture element, while

Fig. 4 shows signals in such a device while using conventional multiple row addressing and

Fig. 5 shows signals in such a device while using multiple row addressing according to the invention.

Fig. 1 shows a display device comprising a matrix 1 of pixels at the area of crossings of N rows 2 and M columns 3 which are provided as row and column electrodes on facing surfaces of substrates 4, 5, as can be seen in the cross-section shown in the matrix 1. The liquid crystal material 6 is present between the substrates. Other elements such as orientation layers, polarizers, etc. are omitted for the sake of simplicity in the cross-section.

The device further comprises a row function generator 7 in the form of, for example, a ROM for generating orthogonal signals $H_i(t)$ for driving the rows 2. Similarly as described in said article by Scheffer and Clifton, row vectors driving a group of p rows via drive circuits 8 are defined during each elementary time interval. The row vectors are written into a row function register 9.

Information 10 to be displayed is stored in a pxM buffer memory 11 and read as information vectors per elementary unit of time. Signals for the column electrodes 3 are obtained by multiplying the then valid values of the row vector and the information vector during each elementary unit of time and by subsequently adding the p obtained products. The multiplication of the values which are valid during an elementary unit of time of the row and column vectors is realized by comparing them in an array 12 of M exclusive ORs. The addition of the products is effected by applying the outputs of the array of exclusive ORs to the summing logic 13. The signals 16 from the summing logic 13 drive a column drive circuit 14 which provides the columns 3 with voltages $Y_j(t)$ having $p+1$ possible voltage levels. Every time, p rows are driven simultaneously, in which $p < N$ ("multiple row addressing"). The row vectors therefore only have p elements, as well as the information vectors, which results in a saving of the required hardware such as the number of exclusive ORs and the size of the summing circuit, as compared with the method in which all rows are driven simultaneously with mutually orthogonal signals ("Active Addressing").

As stated in the opening paragraph, it is possible to use less drive electronics by choosing p to be low, for example, in the range between 3 and 8. Fig. 2 shows a schematically how the display device is driven with a set of orthogonal functions referred to as $H_i(t)$ and the pulse patterns derived therefrom for the purpose of multiple row addressing with $p = 4$. The practical implementation may differ from that of Fig. 1.

The data-vector D $\begin{bmatrix} d[row,col] \\ d[(row+1),col] \\ d[(row+2),col] \\ d[(row+3),col] \\ . \\ . \\ . \\ d[(row+m-1),col] \end{bmatrix}$ with $d[row,col] \in \{-1,1\}$

represents the data to be displayed on the display for all the pixels in column (col), where d[row,col] = 1 stands for an on/off pixel and d[row,col] = -1 stands for an off/on pixel. In Figure 2 a known matrix 21 or matrix A for driving an 8 row and 8 column (mux 8) display 1 has two orthogonal (sub)matrices B $\begin{bmatrix} H11 & H12 & H13 & H14 \\ H21 & H22 & H23 & H24 \\ H31 & H32 & H33 & H34 \\ H41 & H42 & H43 & H44 \end{bmatrix}$ and

C $\begin{bmatrix} H55 & H56 & H57 & H58 \\ H65 & H66 & H67 & H68 \\ H75 & H76 & H77 & H78 \\ H85 & H86 & H87 & H88 \end{bmatrix}$

with $Hxy \in \{-1,1\}$ with are equal and orthogonal. .Each column signal is calculated by multiplying matrix A

$$\begin{bmatrix} H11 & H12 & H13 & H14 & 0 & 0 & 0 & 0 \\ H21 & H22 & H23 & H24 & 0 & 0 & 0 & 0 \\ H31 & H32 & H33 & H34 & 0 & 0 & 0 & 0 \\ H41 & H42 & H43 & H44 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & H55 & H56 & H57 & H58 \\ 0 & 0 & 0 & 0 & H65 & H66 & H67 & H68 \\ 0 & 0 & 0 & 0 & H75 & H76 & H77 & H78 \\ 0 & 0 & 0 & 0 & H85 & H86 & H87 & H88 \end{bmatrix}$$

with the corresponding data-vector D $\begin{bmatrix} d[row,col] \\ d[(row+1),col] \\ d[(row+2),col] \\ d[(row+3),col] \\ . \\ . \\ . \\ d[(row+m-1),col] \end{bmatrix}$.

According to the invention mutually orthogonal signals obtained from at least two different orthogonal functions in one frame can be used. To prove this it must be shown that the rms voltage (or 'rms value') across a pixel does not depend on the orthogonal

matrices B and C used. Because a column signal calculation does not depend on the other column data-vectors closer look at the calculation for column number 1 is taken. The rms value of a continuous signal $f_{(t)}$ is given by:

$$f_{rms} = \sqrt{\frac{1}{T}\int_0^T f_{(t)}{}^2\,dt}$$

For liquid crystal display drive signals the discrete version of the previous formula is needed. For a discrete signal $f_{(i)}$ the rms value is calculated with:

$$f_{rms} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} f_{(i)}{}^2} \qquad [1]$$

To calculate the rms value across the pixel in row 1 and column 1 we need the discrete function $f_{(i)}$ first. From Figure 1 it follows for i = t and n=r=8:

$$f_{(t)} = (H11 - Y_{(t1)}) \text{ for } t = 1, (H21 - Y_{(t2)}) \text{ for } t = 2, \ldots, (0 - Y_{(t8)}) \text{ for } t = 8.$$

Substitution in [1] gives:

$$f_{rms} = \sqrt{\frac{1}{8}\left\{\sum_{i=1}^{4}(H_{i1} - Y_{(t=i)})^2 + \sum_{i=5}^{8}(Y_{(t=i)})^2\right\}} \qquad [2]$$

The $Y_{(t=i)}$ values of the result-vector Y for column 1 is the result of the matrix multiplication of matrix A with data-vector D.

(N.B.For matrix multiplication in general of a *m x n* matrix Q with a *n x p* matrix R resulting in a *m x p* matrix P counts:

$$P_{ij} = \sum_{k=1}^{n} Q_{ik}R_{kj} \;)$$

Using the previous formula the $Y_{(t=i)}$ values are:

$$Y_{(t1)} = H11 \cdot d[1,1] + H12 \cdot d[2,1] + H13 \cdot d[3,1] + H14 \cdot d[4,1] + 0 \cdot d[5,1] + 0 \cdot d[6,1] + 0 \cdot d[7,1] + 0 \cdot d[8,1]$$
$$Y_{(t2)} = H21 \cdot d[1,1] + H22 \cdot d[2,1] + H23 \cdot d[3,1] + H24 \cdot d[4,1] + 0 \cdot d[5,1] + 0 \cdot d[6,1] + 0 \cdot d[7,1] + 0 \cdot d[8,1]$$
$$Y_{(t3)} = H31 \cdot d[1,1] + H32 \cdot d[2,1] + H33 \cdot d[3,1] + H34 \cdot d[4,1] + 0 \cdot d[5,1] + 0 \cdot d[6,1] + 0 \cdot d[7,1] + 0 \cdot d[8,1]$$
$$Y_{(t4)} = H41 \cdot d[1,1] + H42 \cdot d[2,1] + H43 \cdot d[3,1] + H44 \cdot d[4,1] + 0 \cdot d[5,1] + 0 \cdot d[6,1] + 0 \cdot d[7,1] + 0 \cdot d[8,1]$$
$$Y_{(t5)} = 0 \cdot d[1,1] + 0 \cdot d[2,1] + 0 \cdot d[3,1] + 0 \cdot d[4,1] + H55 \cdot d[5,1] + H56 \cdot d[6,1] + H57 \cdot d[7,1] + H58 \cdot d[8,1]$$
$$Y_{(t6)} = 0 \cdot d[1,1] + 0 \cdot d[2,1] + 0 \cdot d[3,1] + 0 \cdot d[4,1] + H65 \cdot d[5,1] + H66 \cdot d[6,1] + H67 \cdot d[7,1] + H68 \cdot d[8,1]$$
$$Y_{(t7)} = 0 \cdot d[1,1] + 0 \cdot d[2,1] + 0 \cdot d[3,1] + 0 \cdot d[4,1] + H75 \cdot d[5,1] + H76 \cdot d[6,1] + H77 \cdot d[7,1] + H78 \cdot d[8,1]$$
$$Y_{(t8)} = 0 \cdot d[1,1] + 0 \cdot d[2,1] + 0 \cdot d[3,1] + 0 \cdot d[4,1] + H85 \cdot d[5,1] + H86 \cdot d[6,1] + H87 \cdot d[7,1] + H88 \cdot d[8,1]$$

Throwing away the zero parts leaves:

$$Y_{(t1)} = H11 \cdot d[1,1] + H12 \cdot d[2,1] + H13 \cdot d[3,1] + H14 \cdot d[4,1]$$
$$Y_{(t2)} = H21 \cdot d[1,1] + H22 \cdot d[2,1] + H23 \cdot d[3,1] + H24 \cdot d[4,1]$$
$$Y_{(t3)} = H31 \cdot d[1,1] + H32 \cdot d[2,1] + H33 \cdot d[3,1] + H34 \cdot d[4,1]$$
$$Y_{(t4)} = H41 \cdot d[1,1] + H42 \cdot d[2,1] + H43 \cdot d[3,1] + H44 \cdot d[4,1]$$
$$Y_{(t5)} = H55 \cdot d[5,1] + H56 \cdot d[6,1] + H57 \cdot d[7,1] + H58 \cdot d[8,1]$$
$$Y_{(t6)} = H65 \cdot d[5,1] + H66 \cdot d[6,1] + H67 \cdot d[7,1] + H68 \cdot d[8,1]$$
$$Y_{(t7)} = H75 \cdot d[5,1] + H76 \cdot d[6,1] + H77 \cdot d[7,1] + H78 \cdot d[8,1]$$
$$Y_{(t8)} = H85 \cdot d[5,1] + H86 \cdot d[6,1] + H87 \cdot d[7,1] + H88 \cdot d[8,1]$$

It now appears that $Y_{(t1)}, Y_{(t2)}, Y_{(t3)}$ and $Y_{(t4)}$ values depend on matrix B and that the $Y_{(t5)}, Y_{(t6)}, Y_{(t7)}$ and $Y_{(t8)}$ values depend on matrix C. When matrices B and C are the same orthogonal matrices the rms value across a pixel is, as stated earlier, correct. Keeping the known orthogonal (sub)matrix B and taking another orthogonal (sub)matrix C and assuming that the rms value does not change, would imply that the part $\sum_{i=5}^{8}(Y_{(t=i)})^2$ of formula [2] should be constant for each orthogonal (sub)matrix C.

So $\sum_{i=5}^{8}(Y_{(t=i)})^2$ should be constant for each orthogonal (sub)matrix.

$$\sum_{i=5}^{8}(Y_{(t=i)})^2 =$$

$$(H55\cdot d[5,1]+H56\cdot d[6,1]+H57\cdot d[7,1]+H58\cdot d[8,1])^2+$$
$$(H65\cdot d[5,1]+H66\cdot d[6,1]+H67\cdot d[7,1]+H68\cdot d[8,1])^2+$$
$$(H75\cdot d[5,1]+H76\cdot d[6,1]+H77\cdot d[7,1]+H78\cdot d[8,1])^2+$$
$$(H85\cdot d[5,1]+H86\cdot d[6,1]+H87\cdot d[7,1]+H88\cdot d[8,1])^2$$

Knowing that $(a+b+c+d)^2 = a^2+b^2+c^2+d^2+2a(b+c+d)+2b(c+d)+2cd$ and $Hxy \in \{-1,1\}$, $d[row,col] \in \{-1,1\}$ it follows:

$$\sum_{i=5}^{8}(Y_{(t=i)})^2 =$$

$$4+$$
$$2\cdot H55\cdot d[5,1](H56\cdot d[6,1]+H57\cdot d[7,1]+H58\cdot d[8,1])+$$
$$2\cdot H56\cdot d[6,1](H57\cdot d[7,1]+H58\cdot d[8,1])+$$
$$2\cdot H57\cdot d[7,1]\cdot H58\cdot d[8,1]+$$
$$4+$$
$$2\cdot H65\cdot d[5,1](H66\cdot d[6,1]+H67\cdot d[7,1]+H68\cdot d[8,1])+$$
$$2\cdot H66\cdot d[6,1](H67\cdot d[7,1]+H68\cdot d[8,1])+$$
$$2\cdot H67\cdot d[7,1]\cdot H68\cdot d[8,1]+$$
$$4+$$
$$2\cdot H75\cdot d[5,1](H76\cdot d[6,1]+H77\cdot d[7,1]+H78\cdot d[8,1])+$$
$$2\cdot H76\cdot d[6,1](H77\cdot d[7,1]+H78\cdot d[8,1])+$$
$$2\cdot H77\cdot d[7,1]\cdot H78\cdot d[8,1]+$$
$$4+$$
$$2\cdot H85\cdot d[5,1](H86\cdot d[6,1]+H87\cdot d[7,1]+H88\cdot d[8,1])+$$
$$2\cdot H86\cdot d[6,1](H87\cdot d[7,1]+H88\cdot d[8,1])+$$
$$2\cdot H87\cdot d[7,1]\cdot H88\cdot d[8,1]$$

In multiple row addressing the rms value for the pixel in row 1 and column 1 can be modified by data d[1,1]. The data belonging to the other pixels in column 1 (d[2,1] and up) do not modify this rms value (otherwise the rms value for a pixel in a column would depend on all data in that column).

Because in above equation data d[1,1] does not occur and with above statement we can substitute d[5,1], d[6,1], d[7,1] and d[8,1] with 1's which simplifies above formula to:

$$\sum_{i=5}^{8}(Y_{(t=i)})^2 =$$
$$16+$$
$$2\cdot H55\cdot(H56+H57+H58)+2\cdot H56\cdot(H57+H58)+2\cdot H57\cdot H58+$$
$$2\cdot H65\cdot(H66+H67+H68)+2\cdot H66\cdot(H67+H68)+2\cdot H67\cdot H68+$$
$$2\cdot H75\cdot(H76+H77+H78)+2\cdot H76\cdot(H77+H78)+2\cdot H77\cdot H78+$$
$$2\cdot H85\cdot(H86+H87+H88)+2\cdot H86\cdot(H87+H88)+2\cdot H87\cdot H88 \qquad [3]$$

When taking a closer look to all the product terms in equation [3] and to the matrix below the condition or rule for a matrix to be an orthogonal matrix.

$$\begin{bmatrix} H55 & H56 & H57 & H58 \\ H65 & H66 & H67 & H68 \\ H75 & H76 & H77 & H78 \\ H85 & H86 & H87 & H88 \end{bmatrix}$$ should be determined.

The rule for a matrix to be an orthogonal matrix is:

$$\sum_{k=1}^{p} H_{ik}\cdot H_{jk} = 0 \text{ for } i \neq j \text{ and} = 1 \text{ for } i = j \qquad [4]$$

Expanding this formula as a sum of products for $i \neq j$ the same sum of products as in [3] is found. Because the result of formula [4] is 0 for $i \neq j$ then also the result of all summations of the product terms in [3] is 0. With this the prove that $\sum_{i=5}^{8}(Y_{(t=i)})^2 = \text{Constant}$ is delivered, so multiple row addressing can use multiple (two or even more) orthogonal matrices within a frame without affecting the rms value of the pixels.

A similar reasoning applies when using orthogonal functions and the pulse patterns derived therefrom for the purpose of multiple row addressing with $p = 8$.
To show the advantage of using multiple orthogonal matrices in the example the average current through a single capacitor (read: the pixel in row 1 and column 1) is determined. As

known the average current through a capacitor for a symmetrical square wave is given by:

$$i_{avg} = C \cdot v \cdot f \qquad [5]$$

where 'C' equals the capacitance of the capacitor of the pixel (capacitor 22 in Figure 3, 'v' the amplitude of the square wave (voltage supply 23) and 'f' the frequency of the square wave see Figure 3).

The average current will increase when 'C', 'v' or 'f' goes up. Because 'C' is related to the used liquid crystal in the display and 'v' is generally fixed for a certain drive scheme, current (and so dissipation) can only be diminished by changing 'f' of drive signal, e.g. by reducing the number of transitions in the signal.

Figure 4 with s = r =8 (mux 8 display) shows an example of the prior art in which all the pixels in all columns from row 1 through row 8 are set to alternating on and off. The data vectors D then are equal to (taking a 1 for an on pixel and -1 for an off pixel:

$$D = \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ -1 \end{bmatrix}$$

Assuming that matrices B and C in Figure 2 are both equal to the following orthogonal matrix:

$$B = C = \begin{bmatrix} -1 & 1 & 1 & 1 \\ 1 & -1 & 1 & 1 \\ 1 & 1 & -1 & 1 \\ 1 & 1 & 1 & -1 \end{bmatrix}$$

the result vector Y for all columns will be:

$$Y = A \cdot D$$

$$Y=\begin{bmatrix}-1&1&1&1&0&0&0&0\\1&-1&1&1&0&0&0&0\\1&1&-1&1&0&0&0&0\\1&1&1&-1&0&0&0&0\\0&0&0&0&-1&1&1&1\\0&0&0&0&1&-1&1&1\\0&0&0&0&1&1&-1&1\\0&0&0&0&1&1&1&-1\end{bmatrix}\cdot\begin{bmatrix}1\\-1\\1\\-1\\1\\-1\\1\\-1\end{bmatrix},\quad Y=\begin{bmatrix}-2\\2\\-2\\2\\-2\\2\\-2\\2\end{bmatrix}$$ compare Figure 4b

The signal across the capacitor (pixel) in row 1 and column 1 (row signal - column signal) for t=1 to t=8 is shown in Figure 4c. Figure 4c shows that the signal across the capacitor changes polarity every time step or selection time. The signal frequency is the highest. According to formula [5] the high signal frequency will result in a high average current. This situation where the signal across each capacitor (again read: pixel) in the display changes polarity each selection time is called the worst case situation for black and white drive schemes. The total average current drawn by the total display is high.

Now, making use of the multiple orthogonal matrix drive transitions by taking an appropriate orthogonal matrix C is significantly reduced e.g. by. keeping matrix B:

$$B=\begin{bmatrix}-1&1&1&1\\1&-1&1&1\\1&1&-1&1\\1&1&1&-1\end{bmatrix}$$ the same and for matrix C taking the orthogonal matrix:

$$C=\begin{bmatrix}-1&-1&1&-1\\1&-1&-1&-1\\1&-1&1&1\\1&1&1&-1\end{bmatrix}$$ the same calculation for the result vector Y results in:

$$Y=\begin{bmatrix}-1&1&1&1&0&0&0&0\\1&-1&1&1&0&0&0&0\\1&1&-1&1&0&0&0&0\\1&1&1&-1&0&0&0&0\\0&0&0&0&-1&-1&1&-1\\0&0&0&0&1&-1&-1&-1\\0&0&0&0&1&-1&1&1\\0&0&0&0&1&1&1&-1\end{bmatrix}\cdot\begin{bmatrix}1\\-1\\1\\-1\\1\\-1\\1\\-1\end{bmatrix},\quad Y=\begin{bmatrix}-2\\2\\-2\\2\\2\\2\\2\\2\end{bmatrix}$$ (Figure 5b) and the signal across the capacitor (pixel) in row 1 and column 1 (row signal - column signal)for t=1 to t=8 will now look as shown in Figure 5c

Compared with Figure 4 is shown in Figure 5 that the row - column signal has changed from a continuos square wave like signal to a burst square wave like signal. The number of transitions of the row - column signal is roughly divided by two. Because of this the average current (and dissipation will also be about the half of the average current for the row - column signal in Figure 4.So, by using an appropriate orthogonal matrix C the total display current needed for displaying the alternating on and off pixels (worst case situation) can be reduced by almost a factor 2.

The invention is of course not limited to the embodiments shown. The logic in the driver IC can make multiple selections from the programmed orthogonal matrices during frames and also after whole frames. Also vectors within an orthogonal matrix can be swapped or inverted by the driver to reduce the number of column signal transitions. Furthermore it is possible to let the driver IC decide which orthogonal matrix it will use for certain display data content. In this way an adaptive multiple orthogonal matrix multiple row addressing drive is created which results in low display current and module power independent of the data to be displayed.

The protective scope of the invention is not limited to the embodiments described. The invention resides in each and every novel characteristic feature and each and every combination of characteristic features. Reference numerals in the claims do not limit their protective scope. The use of the verb "to comprise" and its conjugations does not exclude the presence of elements other than those stated in the claims. The use of the article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

CLAIMS:

1. A display device comprising a liquid crystal between a first substrate provided with row or selection electrodes and a second substrate provided with column or data electrodes, in which overlapping parts of row and column electrodes define pixels, drive means for driving the column electrodes in conformity with an image to be displayed, and drive means for driving the row electrodes which, in the operating condition, within a frame period sequentially supply groups of p row electrodes with mutually orthogonal signals obtained from at least two different orthogonal functions.

2. A display device as claimed in claim 1 in which the orthogonal signals are obtained from orthogonal functions having p elementary units of time.

3. A display device as claimed in claim 1 or 2 in which $p = 4$.

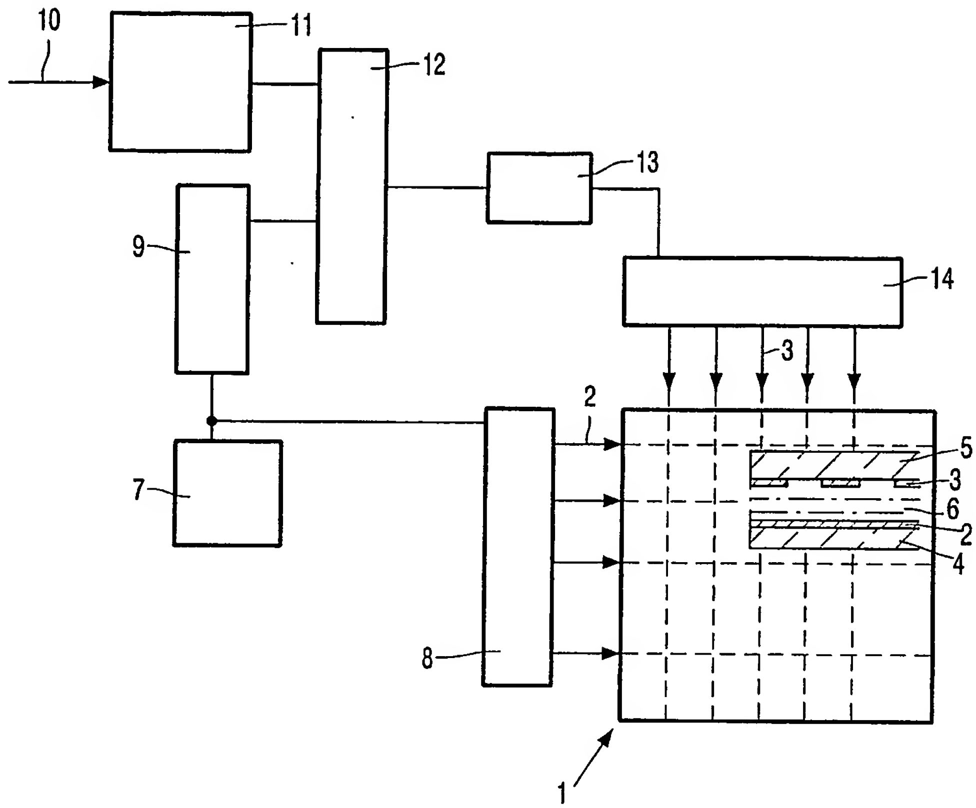

FIG. 1

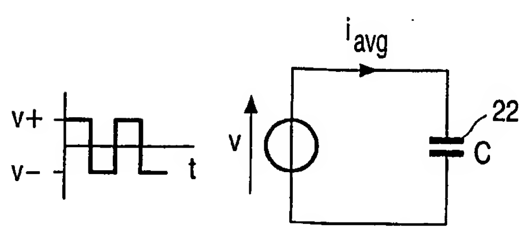

FIG. 3

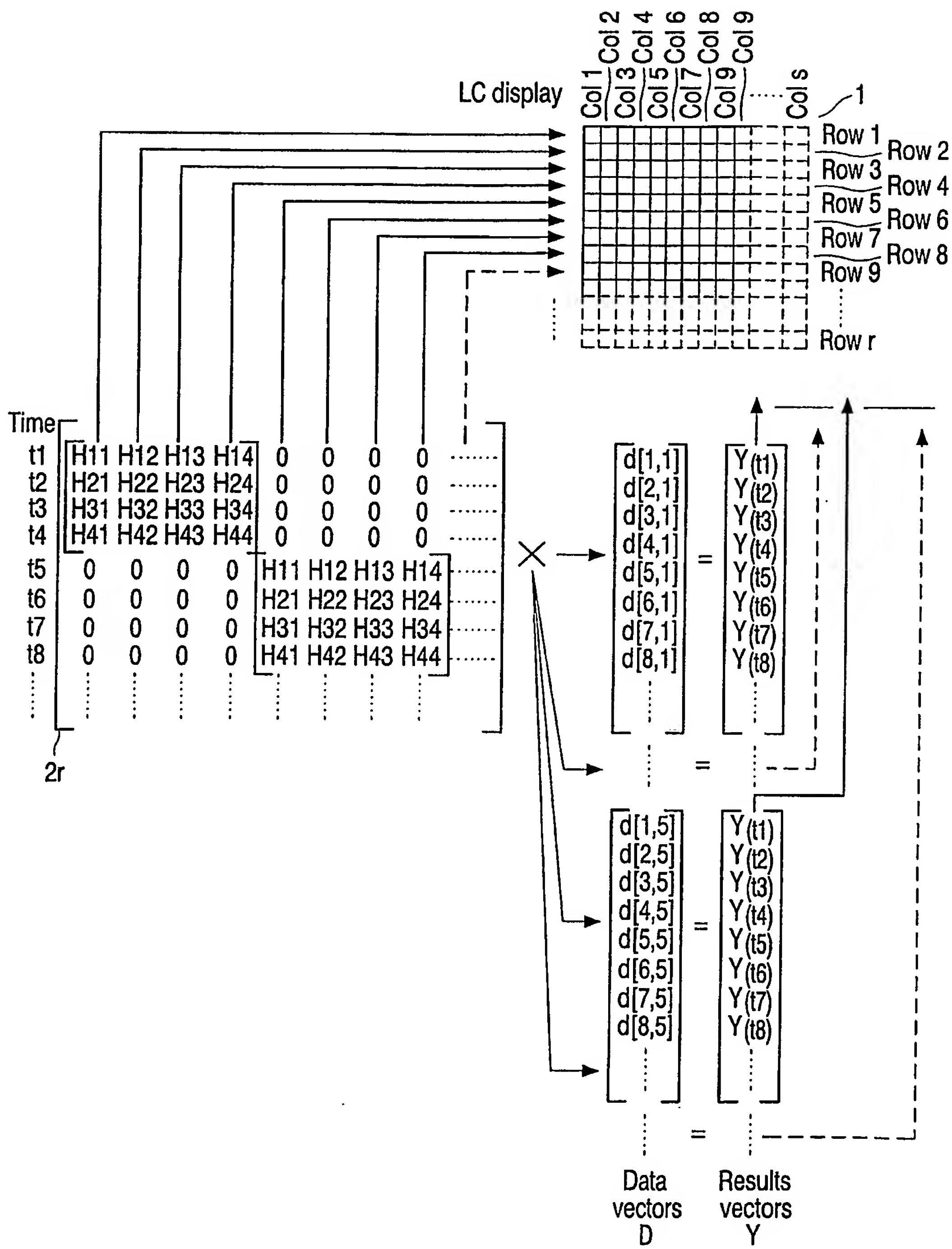
LC display
Col 1
Col 2
Col 3
Col 4
Col 5
Col 6
Col 7
Col 8
Col 9
Col 9
Col s
1
Row 1
Row 2
Row 3
Row 4
Row 5
Row 6
Row 7
Row 8
Row 9
Row r
Time
t1
t2
t3
t4
t5
t6
t7
t8
H11 H12 H13 H14 0 0 0 0
H21 H22 H23 H24 0 0 0 0
H31 H32 H33 H34 0 0 0 0
H41 H42 H43 H44 0 0 0 0
0 0 0 0 H11 H12 H13 H14
0 0 0 0 H21 H22 H23 H24
0 0 0 0 H31 H32 H33 H34
0 0 0 0 H41 H42 H43 H44
2r
d[1,1]
d[2,1]
d[3,1]
d[4,1]
d[5,1]
d[6,1]
d[7,1]
d[8,1]
Y(t1)
Y(t2)
Y(t3)
Y(t4)
Y(t5)
Y(t6)
Y(t7)
Y(t8)
d[1,5]
d[2,5]
d[3,5]
d[4,5]
d[5,5]
d[6,5]
d[7,5]
d[8,5]
Y(t1)
Y(t2)
Y(t3)
Y(t4)
Y(t5)
Y(t6)
Y(t7)
Y(t8)
Data vectors D
Results vectors Y

FIG. 2

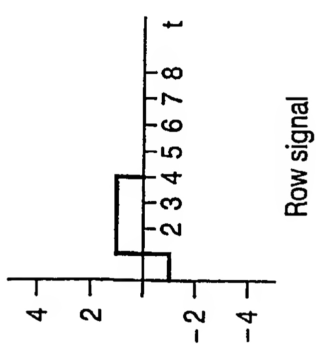

FIG. 4a

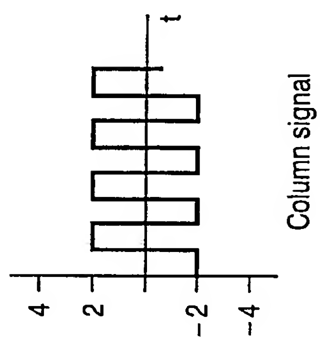

FIG. 4b

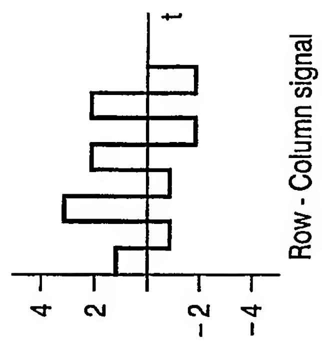

FIG. 4c

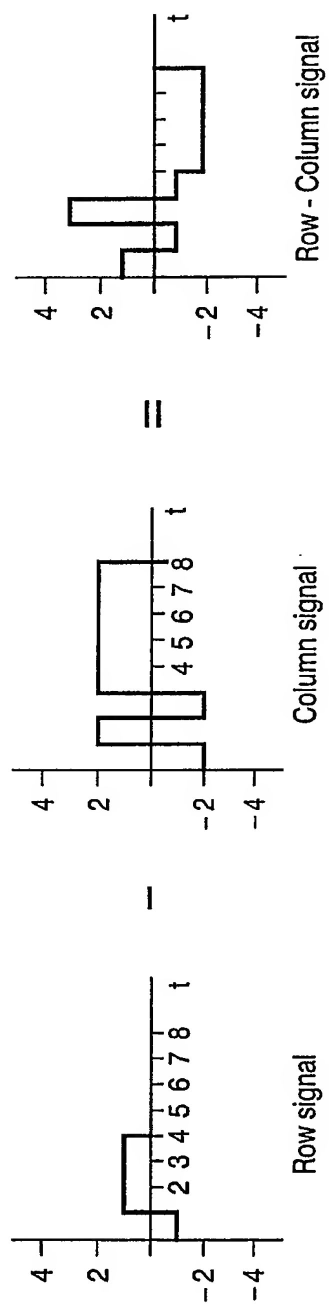

FIG. 5a

FIG. 5b

FIG. 5c